Submission Date: Feb 15, 2008 | Priority: 1 of 1

Ted Stevens
United States Senator for Alaska

Please Note:
- Fill out one request form for each request
- This form (and any attachments) can be returned via:
  Fax - (202) 224-2354
  Mail - The Honorable Ted Stevens
  United States Senate
  522 Hart Senate Office Bldg.
  Washington, D.C. 20510
- **Requests are due by February 15, 2008.**

FISCAL YEAR 2009 PROJECT REQUEST FORM

Project Name: Vanadium Red-Ox Flow Battery Energy Storage Project

Project Location: Kotzebue, Alaska

Project Description (please attach additional pages as required):

See additional Pages

Related Appropriations Bill: EWD/Agriculture

Amount of federal funding requested for FY09: $1,300,000

Total funding to complete this project: $1,725,000

Number of years to fund this project: 1

Matching funds from the State of Alaska:

Matching funds from local and private entities:

Kotzebue Electric Association has committed $75,000.

List legislation that authorizes this project:

There is no authorization for this specific technology, DOE has authorized funding for technologies like this.

Check all that apply:

- ☐ A change in the current law is necessary in order to proceed with the project. (If so, attach language and a list of laws that need to be amended)
- ☐ Bill or report language is needed. (If so, attach requested language)

If this project was funded in prior appropriations bills (within the last five years), list each bill and the amount funded:

We have received $200,000 in funding from the State of Alaska but are again requesting State of Alaska funding through the current legislature. The Department of Energy has also committed $150,000. The total amount of committed funds is $425,000.

Amount included in the President's FY09 Budget: None

Amount included in the State of Alaska FY09 Budget: Pending

☐ Check this box if state funding was sought but not provided.

Project Description:

The objectives of this project are to reduce the use of diesel fuel. This project will enhance the KEA Wind Program whose goals are as follows:

(1) To test and verify wind generation technology applications in wind/diesel hybrid systems and to provide system performance/cost data,

(2) To maximize the reduction in consumption of diesel fuel by KEA through the use of wind power generation,

(3) To develop a cold-weather test site which will assist in the transfer of renewable technology to rural communities, and

(4) To develop a high penetration wind/diesel system that will maximize the use of wind energy.

This project targets the use of a new battery system. One of the major issues associated with wind systems has been energy storage. KEA is proposing the use of a Vanadium Red-Ox Flow Battery System. The use of an efficient battery system will store wind energy and also store diesel energy at night to be used for peaking power.

Energy storage techniques are quickly becoming very critical to the economic viability of rural communities. As the nation begins to restructure the utility industry and incorporate larger amounts of distributed generation (DG) in the form of wind, solar, and geothermal power, utility scale energy storage technologies will be needed in the electrical transmission and distribution system. Renewable technologies cannot be actively controlled to match the load and therefore can cause fluctuations in voltage and frequency which leads to grid system instability [4]. Properly placed energy storage systems could provide peak power to remote areas, reduced voltage loss and flicker, while providing voltage and frequency regulation as well as a spinning reserve [2]

Over time various electrical, mechanical, and electrochemical storage techniques have been used including, but not limited to, flow batteries, fuel cells, flywheels, hydroelectric, solar thermal, hydrogen, hydrocarbon fuels, and bio-fuels. The most common energy storage application is pumped hydroelectric storage with over 80GW of installed capacity globally [2]. However, hydroelectric storage is very site specific. A flow battery is an electrochemical method of storing energy. Meaning that energy is stored by chemical changes in an electrolyte solution which contain one or more dissolved electro-active species [3]. This solution is pumped through a fuel cell to either electrically discharge or charge the system. The typical proton exchange membrane (PEM) fuel cell converts the chemical energy to electrical by dissociating the protons and electrons from the electrolyte solution. The protons move through the existing membrane while the electrons travel along an external circuit which then supplies power.

The VRFB is an electrical energy storage system based on the patented vanadium-based red-ox regenerative fuel cell. Energy is stored chemically in different ionic forms of vanadium in a dilute sulphuric acid electrolyte. One plastic storage tank contains vanadium (V^{4+}/V^{5+}) vanadium and the other is vanadium (V^{2+}/V^{3+}). They are then pumped through a PEM where one solution is electrochemically oxidized and the other is electrochemically reduced. The reaction takes place on inert carbon polymer composite electrodes. As vanadium ions are the only species used the risk of cross contamination of ions through the PEM, which was a previous problem with flow batteries, is eliminated [1].

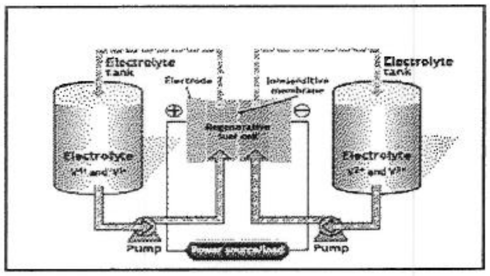

Figure 1: Vandadium Red-Ox Flow Battery Schematic

The critical feature of the VRFB is that the reaction is reversible and can be charged and discharged continually with no loss of efficiency or damage to the system. The system is also very modular and can be designed to meet specific power and storage needs as they are independent of each other. The system power is controlled by the number of cells in the stack and the size of the electrodes while the storage capacity is determined by the concentration and volume of the electrode. The system's storage capacity can be increased by simply adding more electrolyte solution.

The technology to confidently rely on distributed generation is still new. Utilizing an energy storage device, such as a Vanadium Red-Ox Flow Battery (VRFB), would enable an irregular energy source such as wind power, to be stored and then supplied during periods of peak power. Batteries offer power stabilization, load leveling from renewable energy, and could manage power transmission line loads. The Kotzebue installation will reduce peak power load by fifteen percent and by installing high speed data acquisition systems we will be able to thoroughly understand the system dynamics and responsiveness of a wind-battery-diesel hybrid power plant.

VRB Power Systems Inc. (VRB) of Vancouver, BC, Canada has this technology currently in a pre-commercial state. From their experience they find many advantages of a VRFB energy storage system. They are listed verbatim [1]:

Layout & Design

- Rapid design and construction including environmental since no appreciable air, waste or sound emissions are produced. Balance of plant items such as piping, tanks, wiring and inverter are all off-the-shelf and are readily available, enabling rapid construction and commissioning. Expected time from order to commissioning for a multi-megawatt facility is in the 12 – 16 month range.
- Existing systems can be readily upgraded - additional storage capacity can be added (at low

incremental costs) by increasing the volume of electrolyte (liters) and/or output power can be increased by adding additional cell stacks.

Operations & Maintenance

- Low operating temperatures and minimal sensitivity to ambient temperature variations.
- ***<u>SCADA interface via internet or dial up modem.</u>***
- Use of advanced multi-quadrant power flow control allowing phase control of outputs, voltage sag/dip compensation, low harmonic distortion, reactive power flow compensation, high short term and instantaneous overload capacity – ideal for stability enhancement. Multi-layer, encrypted password access to the control PLC.
- Designed for unattended (remote) operation with very low maintenance costs.

Performance

- Availability of greater than 98%.
- No degradation from repeated deep charges and discharges. The VRB-ESS membrane has been charged and discharged more than 13,000 times in a laboratory setting without deterioration of system efficiencies.
- System round-trip efficiencies of 65 - 75%.
- Charge/discharge ratio of 1:1 – a significantly higher charge rate than other battery systems and ideal for wind generation applications.

Electrolyte

- Cross mixing of electrolytes does not lead to the contamination of electrolytes.
- Indefinite life of electrolyte - no disposal or contamination issues and high residual values at the end of plant life.
- Low self-discharge.

Environmental

- Characterized by the lowest ecological impact of all energy storage technologies and unlike most conventional energy storage systems, does not rely on toxic substances such as lead, zinc or cadmium.
- An assessment of the environmental impact of both VRB-ESS and lead-acid batteries for use in stationary applications indicates that the VRB-ESS produces 75 - 93% fewer emissions of key environmentally damaging components (CO_2, SO_2, CO, CH_4, NO_x) during its life cycle.

Project Justification:

This project has the ability to dramatically increase the use of wind energy and reduce the use of fossil fuels for rural Alaska.

Alaska is a large state geographically with a very small population. In terms of energy this means huge distances between utilities with minimal loads. Most of Alaska is not accessible by roads. Access for most rural villages is by air or water, making energy costs extremely high – as much 250% above the national average. In 2007, the average cost of power in Anchorage-Fairbanks-Juneau for residential customers was 10 cents/kWh, whereas in rural communities, the average residential cost of power is $0.42/kWh for 2007. In Alaska, ninety utilities service 187 rural communities. Approximately 70,000 people, or 13% of the state's population, live in communities whose primary source of electricity is diesel fuel. These communities are characteristically small (populations of 400 or less), remote and accessible only by air or by seasonal barge service. Efforts need to continue attempts to alleviate the burden in these communities of continued dependence on diesel fuel.

Many communities in rural Alaska have excellent to superb wind resource potential with a wind power density greater that 500 Watts/m^2. Several communities already have or are planning to install wind farms which will help to offset the high cost of diesel. Wind plants without any energy storage are not fully optimized. There is little control over when and how strong the wind will blow and it won't exactly match the times of peak power requirements. Having energy storage available will allow excess power to be absorbed and then released during times of larger loads.

General benefits a Vanadium Red-Ox Flow Battery in rural Alaska include:

- Lower electricity generation costs
- Low environmental risks and damage because the electrolyte is contained and diesel consumption is reduced.
- Decreased reliance on the State of Alaska's Power Cost Equalization program
- Increased self-reliance by allowing more use of renewable local energy resources.
- More of the money needed to generate electricity can be spent locally and benefit the local economy.
- Overall improvement of electrical distribution infrastructure asset utilization and load factor
- New construction and maintenance jobs for rural Alaskans
- Power quality and reliability improvement for electric customers
- Constant voltage regulation, VAR support, and power quality benefits
- Overall improvement of electrical distribution infrastructure asset utilization and load factor

KEA is in the process of upgrading the diesel power plant in order to accept higher penetration of wind resources. During the past several years the Kotzebue Electric Association wind project has seen periods of penetration of 35% wind on its electric system. Wind penetration beyond this without storage and better controls (currently being added) would make the Kotzebue grid unstable. A previous rule of thumb was that in excess of 25% penetration using induction-generated wind on a distribution system could cause system instability. Although, the characteristics of the newer electronic governors allow greater frequency control of the wind/diesel system up to approximately 40%, higher levels are likely to affect system stability. To deal with the higher levels of wind penetration a greater level of power plant control has been installed.

The purpose of the Kotzebue project was to construct and demonstrate an energy control and storage system which would integrate a large proportion of wind energy into a small diesel grid, while maintaining system stability, and making optimum use of excess energy. The project by its nature was expensive due to the complexity of the energy use and the overlying control of four separate subsystems:

(1) The diesel plant and its subsystems,
(2) The wind system,
(3) The use of thermal energy from the diesels at the power plant and the school, and
(4) *Now the addition of an energy storage system*

BIBLIOGRAPHY

[1] VRB Power. "The VRB Energy Storage System-An Introduction to Wind & the Integration of a VRB-ESS." March 2, 2007

[2] W. Steeley. "VRB Energy Storage for Voltage Stabilization- Testing and Evaluation of the Pacificorp Vanadium Redox Battery Energy Storage System at Castle Valley, Utah." March 2005

[3] Wikipedia, "Fuel Cells," Wikipedia, The Free Encyclopedia, 2007.

[4] Borbely, Anne-Marie and Jan F. Kreider. Distributed Generation-The Power Paradigm for the New Millennium. Pgs 18-19. CRC Press, 2001.

Project Budget Outline:

Since the FY08 funding request this project has changed slightly in scope causing an increase in project cost. Originally, the battery was designed to fit inside the existed power plant building. However, the flow battery will now be housed in a separate building causing a cost increase of $225,000.

Capital Cost Estimate: VRFB Energy Storage System			a. Total Cost
1		Administrative and legal costs	$48,782
2		Land, structures, rights-of-way, appraisals, etc.	0
3		Relocation expenses and payments	$4,068
4		Architectural and engineering fees	$30,000
5		Other architectural and engineering fees	0
6		Project inspection fees	$5,000
7		Site work	$347,000
8		Demolition and removal	0
9		Construction	$0
10		Equipment	$1,200,000
11		Miscellaneous	$40,000
12		Subtotal	$1,674,850
13		Contingencies	$50,246
14		Subtotal	$1,725,096
15		Project income	0
16		Total Project Costs	$1,725,096

Figure 2: Budget Outline VRFB Energy Storage System

Figure 3: Kotzebue Electric Association, Inc.
Vandadium Red-Ox Flow Battery Energy Storage System
Cost Estimate

#	Item	No	Units	$/Unit	Materials	Wt (lbs)	Type	Rate	Freight	No	Units	Rate	Labor & Engr	Total	Notes
1	**Equipment**														
2	VRB Energy Storage System	1	ea	$1,200,000	$1,200,000									$1,200,000	
3	*Includes all equipment necessary for install*														
6	**Site Civil Work**														
7	Excavation Work	1	ea	$57,000.00	$57,000									$57,000	
8	Foundation Materials and Slab Work	1	ea	$170,000.00	$170,000									$170,000	
9	Pre-Fabricated Steel Building	1	ea	$50,000	$50,000									$50,000	
10	Building Erection	1	ea	$30,000	$30,000									$30,000	
	Interior Modifications	1	ea	$40,000	$40,000									$40,000	
	Civil Design									1	lot		$30,000	$30,000	
23	**Permits**														
24	Engineering Inspection Fees									1	lot	$5,000	$5,000	$5,000	
26	**Freight**														
27	VRB Energy Storage System	1	ea				Barge		$40,000					$40,000	
31	**Travel**														
32	ANC-OTZ-ANC	6	ea	$678.00	$4,068									$4,068	
33	Hotel accommodations	0	ea	$120.00	$0									$0	1
35	**Grant Administration**									0	hrs	$65.00	$0	$0	2
36	Subtotal Materials, Freight, Labor, Travel													$1,626,068	
37	Project Management			3%	$48,782									$48,782	
38	Contingency	1	ea	3.0%	$50,246									$50,246	
40	Total													$1,725,096	

Notes:

1 Assumes contractors can utilize KEA's apartment.

2 Not included in Project Management or Contingency